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Improved Mobile Communications Antenna and Transceiving Apparatus

Background of the Invention

Field of the invention

The present invention relates to an antenna apparatus and the accompanying transmitting and receiving apparatus. More particularly, the present invention relates to an improved small antenna, and transmitting and receiving apparatus, for use with a mobile communication terminal.

Background

Conventionally, inverted F-type antennas have been used in mobile communications terminals. These types of antennas may be small and may provide for easy adjustment of impedance. Examples of such antennas are described in Published Unexamined Patent Application No. 11-154815 which is hereby incorporated by reference in its entirety for the purpose of background education.

However, if there is a conductor or a dielectric material located in the direction of the electromagnetic wave radiation transmission or receipt, an inverted F-type antenna often cannot satisfactiorily perform its antenna functions. Especially, for mobile communication terminals, position and space for placing an antenna apparatus are limited and various metals and dielectric materials are placed near the antenna apparatus, so that it can be difficult for the antenna to perform satisfactorily.

It is therefore an object of the present invention to provide an antenna apparatus, and accompanying transmitting and receiving apparatus, which can solve the above-described problems. This purpose is achieved by combinations of characteristics described in the independent claims appended hereto. In addition, appended dependent claims describe further advantageous embodiments of the present invention.

Summary of the Invention

According to a first embodiment of this invention, an antenna apparatus, and a transmitting and receiving apparatus accompanying the antenna apparatus, comprising a rod-shaped antenna element, a feeding part to feed signals to the antenna element, a first ground plane that is provided parallel to and near the antenna element behind a radiating direction in which the antenna element radiates electromagnetic waves, and a second ground plane that is provided parallel to and near the antenna element and which is oriented in a direction different from that of the first ground plane, are provided.

In the above-described summary of this invention, all characteristics necessary for this invention are not listed, and subcombinations of these characteristics may embody the present invention.

Brief Description of the Drawings

Embodiments of the present invention will be described in some detail in the following specification and with reference to the following figures in which like elements are referred to using like reference numbers and in which:

Figure 1 is a perspective view of a transmitting and receiving apparatus in accordance with an embodiment of the present invention;

Figure 2(a) is a perspective view of an antenna apparatus in accordance with an embodiment of the present invention;

Figure 2(b) is a front view of the antenna apparatus of Figure 2(a);

Figure 2(c) is a side view of the antenna apparatus of Figure 2(a);

Figure 3(a) is a perspective view of an antenna apparatus in accordance with an alternate embodiment of the present invention;

Figure 3(b) is a side view of the antenna apparatus of Figure 3(a);

Figure 4 is a graph indicating the antenna gain of an antenna apparatus embodying the present invention when the main body of the transmitting and receiving apparatus is closed; and

Figure 5 is a graph indicating the antenna gain of an antenna apparatus embodying the present invention when the main body of the transmitting and receiving apparatus is opened.

Detailed Description of Embodiments of the Present Invention

Hereinafter, the present invention will be explained by way of description of exemplary embodiments, however, these embodiments should not be read as limiting the invention's scope which shall be delineated solely by the claims appended hereto. In addition, all combinations of characteristics explained in these embodiments are not necessary for each implementation of the invention.

Figure 1 shows a schematic view of a transmitting and receiving apparatus 10 embodying the present invention. The transmitting and receiving apparatus 10 has a display part 20 having a display panel 25 to display information to users, an antenna apparatus 30 provided on the side of the display panel 25, and a main body part 40 connected to the display panel 25 so as to be opened or closed. The transmitting and receiving apparatus 10 may communicate wirelessly with other wireless components when the main body part 40 is open or closed.

The antenna apparatus 30 includes an antenna element 300 that radiates and receives electromagnetic waves, and is used by the transmitting and receiving apparatus 10 to communicate with other wireless apparatus. The main body part 40 includes a communication part 400, which communicates using electromagnetic energy that is fed to the antenna element 300 or which the antenna element 300 receives from the outside. In addition, the main body part 40 is connected to the display panel 25 so as to be opened and closed, and the display panel 25 is shielded from the outside when it is closed.

Figure 2(a) shows a perspective view of the antenna apparatus 30, and Figure 2(b) shows a front view of the antenna apparatus 30. In addition, Figure 2(c) shows a side view of the antenna apparatus 30. The antenna apparatus 30 is an antenna apparatus which may be used for wireless communication in accordance with wireless communications standards such as Bluetooth, among others, and has an antenna element 300, a feeding part 310 that connects a communication part 400 to the antenna element 300, a

first ground plane 320, a second ground plane 330, a first ground connection part 340 and a second ground connection part 350.

The antenna element 300 is a rod-shaped plane, and the plane of the antenna element 300 is largely parallel with the side of the display panel 25. With this arrangement, the capacitance which occurs between the antenna element 300 and a plane-shaped conductor provided on the display panel 25, e.g., a ground electrode in the case that the display panel 25 is an LCD panel, can be reduced. In addition, if the main body part 40 is closed, the capacitance which occurs when a conductor of the metal case that constitutes the main body part 40 is positioned near the antenna element 300, can be reduced.

The feeding part 310 has a core-wire 312 and a shield part 314. The core-wire 312 feeds to a feeding point of the antenna element 300 which is not on an edge of the antenna element 300. For example, the core-wire 312 feeds to a feeding point which is separated from an edge of the antenna element 300 by a predetermined interval, so that impedance of the antenna apparatus 30 is adjusted to a predetermined impedance of a cable that connects the antenna apparatus 30 and the communication part 400.

The shield part 314 is a braided component, which shields electric and magnetic fields that the core-wire 312 receives from the outside, and is connected on a tangent line of the first ground plane 320 and the second ground plane 330. This orientation helps make the radiation of electromagnetic waves approximately the same for when the radiation is in a direction away from (or primarily approximately perpendicular to) the first ground plane 320 as when the radiation is in a direction away from the second ground plane 330.

The feeding part 310 is provided in a perpendicular direction in relation to the first ground plane 320 and from the opposite side of the tangent line in the first ground plane 320 with the second ground plane 330, and provided in a perpendicular direction in relation to the second ground plane 330 and from the

opposite side of the tangent line in the second ground plane 330 with the first ground plane 320. Therefore, the antenna apparatus 30 has a necessary minimum ground plane behind (or as a background to) a radiating direction of the electromagnetic waves from the antenna element 300. This enables the antenna apparatus 30 to be minimized in size, so that the antenna apparatus 30 can be placed in a smaller space of the side of display panel 25.

The first ground plane 320 is provided behind (or oriented as a background to) a radiating direction, in which the antenna element 300 radiates electromagnetic waves, so as to be parallel to and near the antenna element 300. The separation may be a distance of 1/4 wavelength or less of the electromagnetic waves radiated by the antenna element 300, or preferably, a distance of 1/8 wavelength or less. More preferably, it may be a distance of 1/16 wavelength or less. As one example, the first ground plane 320 is provided at a distance of from 2 to 3 mm from the antenna element 300.

The second ground plane 330 is provided behind (or oriented as a background to) a radiating direction, in which the antenna element 300 radiates electromagnetic waves, so as to be parallel to and near the antenna element 300, however, its normal direction is different from that of the first ground plane 320. For example, it is preferable that the second ground plane 330 is approximately perpendicular to the first ground plane 320. This enables the antenna apparatus 30 to effectively radiate electromagnetic waves through a wide range of directions with one or both of the first ground plane 320 and the second ground plane 330 serving as a background to the radiation.

In addition, it is preferable that the distance between the first ground plane 320 and the antenna element 300 is approximately the same as that between the second ground plane 330 and the antenna element 300. This helps create similar transmission and reception properties of the antenna element 300 in each direction.

The first ground connection part 340 connects an edge of the antenna element 300 to the first ground plane 320. The second ground connection part 350 connects an edge of the antenna element 300, e.g., the edge connected to the first ground plane 320, to the second ground plane 330. Therefore, the antenna apparatus 30 has a structure of two combined inverted F-type antennas having mutually different orientations. Alternatively, the antenna apparatus 30 may also have a structure of two combined two L-shaped antennas having mutually different orientations. Therefore, the core-wire 312 may also feed to an edge of the antenna element 300.

As described above, the antenna apparatus 30 effectively radiates electromagnetic waves in directions such that each of the first ground plane 320 and the second ground plane 330 serves as the background (that is, away from each ground plane). For example, if the main body part 40 is closed and radiation of electromagnetic waves in directions away from the second ground plane 330 is blocked, the antenna apparatus 30 can communicate with the outside through radiation of electromagnetic waves in directions away from the first ground plane 320.

Figure 3(a) shows a perspective view of the antenna apparatus 30 in an alternate embodiment of the present invention. Figure 3(b) shows a side view of the alternate embodiment of the antenna apparatus 30. The antenna apparatus 30 in this example further comprises an elastic body part 360 connected to an edge of the antenna element 300. In addition, the antenna apparatus 30 may not have the first ground connection part 340 and the second ground connection part 350. Otherwise, the antenna apparatus 30 of this embodiment is the same as that described above and shown in Figure 2. The discussion below will further describe the elements of this alternate embodiment which differ from the embodiment already discussed.

The elastic body part 360 is an elastic body in the shape of a rectangular parallelepiped, the perimeter of which is made of a conductive material and the inside of which is made so as to be non-conductive; such as an EMI gasket. By contacting a surface

of the elactic body part 360 to the first ground plane 320, the elastic body part 360 connects an edge of the antenna element 300 to the first ground plane 320. In addition, by contacting another surface of the elastic body part 360 to the second ground plane 330, the elastic body part 360 connects an edge of the antenna element 300 to the second ground plane 330.

In addition, as a further example, the elastic body part 360 may comprise a cube which has a side of a length that is approximately the same as the distance between the antenna element 300 and the first ground plane 320. By being pressed downwardly between the antenna element 300 and the first ground plane 320, the elastic body part 360 is attached.

Alternatively, the elastic body part 360 may also be a cube which has a side somewhat longer than the distance between the antenna element 300 and the first ground plane 320. In this case, by being pressed downwardly, the length of the side of the elastic body part 360 is compressed to the distance between the antenna element 300 and the first ground plane 320. With this method, the elastic body part 360 can more securely be attached between the antenna element 300 and the first ground plane 320.

In accordance with this alternate embodiment of the present invention, variation of antenna properties in the manufacturing process can be reduced and manufacturing costs can be decreased, as compared to the embodiment discussed above. For example, according to the embodiment shown in Figure 2, if the first ground connection part 340, which is made of metals and other materials, is formed by stamping, errors in length or width may occur. In addition, if the first ground connection part 340 is attached to the antenna element 300 by welding or soldering, errors may occur at the attachment position. In the event of such errors, the antenna apparatus 30 may exhibit performance properties different from those intended by the design. In contrast, in accordance with the alternate embodiment, for example, the elastic body part 360 is attached by being pressed downwardly between the antenna element 300 and the first ground plane 320. Therefore, if the first ground plane 320 is attached

to the antenna element 300, it is unlikely that attachment errors will occur. Furthermore, compared with welding or soldering, attachment by pressing downwardly is low in manufacturing costs.

Figure 4 illustrates antenna gain of the antenna apparatus 30 when the main body part 40 is closed. Specifically, this figure shows antenna gain in different directions in a horizontal plane with the solid line illustrating gain when the transmitting and receiving apparatus 10 is leaned forward 45 degrees from the horizontal plane. The dotted line illustrates antenna gain using a conventional antenna apparatus instead of the antenna apparatus 30 of the present invention. As is clear from this figure, antenna gain of the antenna apparatus 30 is higher than that of the conventional antenna in almost all angles. Additionally, the antenna gain experienced using the antenna apparatus 30 of embodiments of the present invention is more constant across different angles in the horizontal plane than is the gain experienced utilizing a conventional antenna apparatus.

For clarity, a conventional antenna apparatus is assumed to have, for example, a structure in which the first ground plane 320 and the first ground connection part 340 are removed from the antenna apparatus 30 shown in the present invention.

Figure 5 illustrates antenna gain of the antenna apparatus 30 when the main body part 40 is opened. Specifically, this figure shows antenna gain in different directions in a horizontal plane with the solid line illustrating the gain experienced when the main body part 40 is opened perpendicular to the display panel 25 and the transmitting and receiving apparatus 10 is placed horizontally. The dotted line illustrates antenna gain using a conventional antenna apparatus under the same circumstances instead of the antenna apparatus 30 of the present invention. As is clear from this figure, the antenna gain of the antenna apparatus 30 is higher than that of the conventional antenna in almost all angles.

As is clear from the above description, since the antenna apparatus 30 radiates electromagnetic waves such that each of the

first ground plane 320 and the second ground plane 330 serves as a background, the antenna apparatus 30 can effectively communicate with the outside when the main body part 40 is either opened or closed.

The present invention has been explained in some detail be describing one or more exemplary embodiments. However, it is to be understood that the scope of the present invention is not restricted to the range of the above-described embodiments. Those skilled in the relevant arts will readily recognize that various changes or modifications may be made to the described embodiments without departing from the scope and spirit of the present invention.